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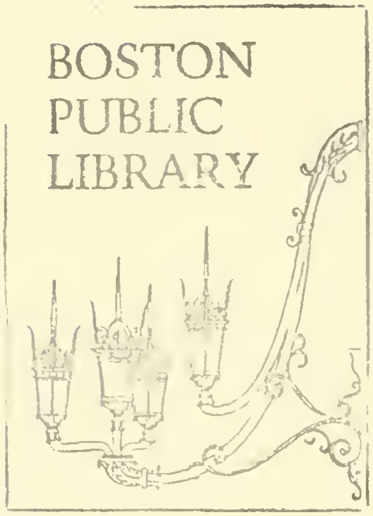

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## PRELIMINARY REPORT

## LEAKAGE INVESTIGATION
## COPLEY SQUARE PARK FOUNTAIN
## BOSTON, MASSACHUSETTS

3 January 1990

DRAFT

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As you requested, we have made a preliminary investigation of the leakage problems at the above-named project. This letter is a report of our Phase I investigation; it documents our field observations and review of project documents; we present general conclusions concerning the design and construction of the Fountain, and we include broad-form recommendations for remedial work.

### 1.0 INTRODUCTION

Construction of the Copley Square Park started in August of 1987 and was completed in the summer of 1989. The Fountain, which consists of an upper pool located above a pipe vault and a lower pool on grade, was operated for a few weeks and then shut down because of leakage problems.

In November 1989, the Boston Redevelopment Authority (BRA) retained Simpson Gumpertz & Heger Inc. (SGH) to investigate leakage and related problems at the Copley Square Park Fountain. Our assignment is divided into two phases: Phase I is to establish the nature of the leakage problems, to evaluate the general adequacy of the Fountain's design and construction, and to provide recommendations for corrective work; Phase II, if authorized by the BRA, is an in-depth investigation and report of the problems noted in Phase I. Phase II will consist of a thorough review of design and construction documents, and selective disassembly of various Fountain and vault components; all of which will be documented in a comprehensive report that assesses responsibility for the problems among the various parties involved in design and construction.

## 2.0 INFORMATION OBTAINED FROM OTHERS

The BRA gave us a set of contract documents for the Reconstruction of Copley Square Park, City of Boston, Massachusetts, which were produced by Clarke & Rapuano Inc., consulting engineers and landscape architect. The documents contain 34 drawings: most are dated 22 June 1987, a few are dated 27 April 1987, and the plumbing and electrical drawings are dated 1 July 1987. The documents also contain contract specifications published by Clarke & Rapuano, Inc. on 22 June 1987 with Addendum No. 1 dated 17 July 1987.

The BRA also gave us a set of four (4) shop drawings produced by Moliterno Stone Sales, Inc. that are revision-dated to 15 June 1987. These drawings show installation details for the granite used to clad the Fountain pools.

We reviewed these documents to establish the basic design and function of the Fountain and underground vaults.

### 2.1 Review of Design Drawings

The Copley Square Park has a Fountain with an upper pool that borders the north edge of the park along Boylston Street, and a lower pool adjacent to, and south of, the upper pool. The balance of the Park consists of landscape areas on grade containing grass lawns and stone pavements. The structure of the upper pool is formed by the reinforced concrete roof of the pipe tunnel located directly below the pool. The pipe tunnel houses pipes and electrical boxes that service the Fountain. Just north of the upper pool, two additional vaults are located below the sidewalk pavement of Boylston Street. One of the vaults contains pumping and electrical equipment for the Fountain, the other vault contains electrical control panels for utilities located throughout the Park and also contains a storage room. For the purposes of this report, we have labeled these three areas individually as the pipe tunnel, pump room and utility vault, and collectively as the underground vaults. Figure 1 of this report contains a plan of the underground vaults and a section taken through the centerline of the Fountain that shows the relationship of the Fountain to the underground vaults.

## Upper Pool

The upper pool consists of three segments separated by the bases of the two fountain spires. At each end of the upper pool, there are planter beds and areaways with air vents to the pipe tunnel below. Drawings 20 and 21 contain typical sections and details for the Fountain, which show, in part, the following:

- Sections SA/20 and SB/20 (Appendix A-1 and A-2) show typical sections through the upper pool, which consists of a reinforced concrete sub-structure, waterproofing membrane, and a 1-1/4 in. thick stone paving set in a 1 in. thick mortar bed. The perimeter of the pool is formed by short concrete walls that are clad with 1-1/4 in. thick granite veneer set into a 1-3/4 in. thick mortar bed. The top of the wall is capped with a 6 in. coping stone set on a 2 in. thick mortar bed.

- Detail S2/21 (Appendix A-3) shows the typical flashing condition at the perimeter wall and coping stone: the waterproofing membrane continues up the interior face of the concrete wall and laps onto a 20 oz continuous copper flashing set into the top of the concrete wall. The copper flashing extends vertically into the concrete wall 3 inches; the height of the flashing above the concrete wall is not shown. The 6 in. high coping stone has a slot cut into its bottom face that allows the stone to fit over the copper flashing.

- The operating level of the water in the pool varies between elevation 20.36 ft and 20.71 ft. The top of the perimeter coping is at elevation 21.0 ft. The high water level of the pool is shown as being above the top of the perimeter copper flashing.

- At the south edge of the pool, granite (stone) overflow channels allow water to flow from the upper pool into the lower pool. Detail S3/21 (Appendix A-4) shows the channels oriented perpendicular to the coping stones; the top of the channel is flush with the top of the coping stones. The waterproofing membrane of the pool continues under the overflow channel and terminates at the edge of the pool; this membrane termination is below the general level of the perimeter flashing.

- Section SA/21 (Appendix A-4) contains a note that states "caulk all around" at the intersection of the perimeter coping stone and the overflow channel; no detail is shown for terminating the copper flashing at its intersection with the channel.

- The bases of the two spires consist of concrete sub-structures that divide the upper pool into three sections. The concrete sub-structure is stepped inward to form a small platform on which the spires rest. Section SC/20 (Appendix A-5) shows the stepped surfaces are clad with stone; no waterproofing membrane is shown to cover the concrete sub-structure above the level of the pool.

- Waterproofing details are not shown for the intersection of the spire bases with the overflow channels at the south side of the pool. However, the geometry of the spire base and its stone veneer are similar to the typical perimeter coping stone condition.

**Lower Pool**

The lower pool is situated on grade, approximately 5 ft below the upper pool. The perimeter of the lower pool consists of stairs formed by a stepped concrete sub-structure clad with granite treads. The stairs are built into the adjacent landscaping. The north side of the lower pool abuts the south wall of the pipe tunnel.

- The lower pool consists of a concrete slab on grade, waterproofing membrane, and 1-1/4 in. thick paving stones set into a 3 in. thick mortar bed.

- The waterproofing membrane returns up the face of the wall that separates the upper and lower pools, and terminates at elevation 17.25, approximately 3 ft below the top of the wall. The wall between the upper and lower pools is penetrated by six skimmer boxes that control the level of water in the lower pool, and by a special events box (electrical box). All of these penetrations occur below the top of the waterproofing membrane; the skimmer boxes are shown on Fig. F-6 of the specifications as having a soldered copper flashing flange to receive the waterproofing membrane. Waterproofing details for the special events box are not shown.

- Section SV/18 (Appendix A-6) shows the pool waterproofing membrane continuing up the concrete sub-stair structure at the perimeter of the pool. The waterproofing membrane is penetrated by straps and dowels that secure the veneer stones, which cover the membrane and concrete sub-structure.

### Pipe Tunnel, Pump Room and Utility Vault

The pipe tunnel, pump room, and utility vault are interconnected to form an underground vault located below the upper pool and the sidewalk of Boylston Street. They consist of new reinforced concrete slabs and walls, or in the case of the pump room, existing concrete slabs and walls. Access to the pipe tunnel is provided by a hatch set into the sidewalk just north of the upper pool. Access to the utility vault is provided by two hatches in the sidewalk at Boylston Street.

- The exterior walls of the pipe tunnel are to be covered with dampproofing and a drainage composite that wraps a footing drain. The footing drain is shown above the level of the joint between walls and base slab. The south wall of the pipe tunnel, which is adjacent to the lower pool, does not have dampproofing or drainage materials.

- The pump room is situated between the pipe tunnel and utility vault and is primarily a pre-existing structure. Section SD/20 (Appendix A-7) shows only a portion of the roof as being covered by a waterproofing membrane.

- The utility vault is a new reinforced concrete structure with a flat roof slab. The roof is covered with a waterproofing membrane that extends 2 ft–3 in. down the exterior walls. The balance of the walls are covered with dampproofing and a drainage composite that wraps a footing drain. The footing drain is shown above the level of the joint between walls and base slabs.

- Water stops are shown in some joints between walls and base slabs of the underground vaults. The drawings do not clearly indicate that water stops are to be installed at all wall-to-base-slab joints.

## 2.2 Contract Specifications

Section 621 - Fountain and Vault - General Construction states in part:

Membrane waterproofing is to be applied to the roof of the vault in accordance with Section 965 of the Standard Specifications for Highway Bridges (SSHB), Commonwealth of Massachusetts.

Dampproofing is to be applied to exterior concrete surfaces in accordance with Section 970 of SSHB.

- Section 965 of the SSHB is entitled "Membrane Waterproofing and protective course for Bridge Decks" and it contains generalized requirements for the insallation of three generic waterproofing systems: coal tar emulsion reinforced with 2 plies of glass fabric, Hot Applied Rubberized Asphalt, and preformed sheet systems – either reinforced rubberized asphalt or reinforced tar and resin. The project specifications require the protection course to be a 1 in. layer of cement mortar, rather than the bituminous concrete required by the cited standard.

- Sub Section 621.2 – Granite Work states that waterproofing is to be Laticrete 301/305 trowel applied waterproof membrane. The membrane is to be applied to all interior surfaces of the pools in accordance with the membrane manufacturer's instructions.

### 2.3 Moliterno Shop Drawings

- Sections D/2 and F/2 show the north and south perimeter walls of the upper pool, respectively. The top of the copper flashing and membrane is 4 in. down from the top of the coping stone (elev. 21.0 ft). The veneer panels at the inside face of the pool are secured by straps anchored through the waterproofing membrane and into the concrete sub-structure.

## 3.0 FIELD OBSERVATIONS

On 28 November 1989, Stephen S. Ruggiero of Simpson Gumpertz & Heger Inc. (SGH) visited the Copley Square Park to make exterior observations of the Fountain pools and interior observations at the underground vaults. During this visit he met with Mr. Herman Sudholz of the Centennial Committee, who described some of the construction history and past leakage problems at the Fountain. On 6 December 1988, Stephen Ruggiero returned to the Park with David L. Adler of SGH, to make additional exterior observations of the Fountain. At the time of our visits, all of the coping stones had been removed from the perimeter walls of the upper pool. Most of the paving stones and setting bed had also been removed at the south side of

the upper pool. These removals were apparently part of an effort by others to evaluate the leakage problems. Our observations during these visits are summarized below.

## 3.1 General Observations

The Fountain consists of an upper pool separated into three sections by the bases of the two spires. The north side of the upper pool borders the Boylston Street sidewalk, which is covered by blue stone and brick paving (Photo 1). The south edge of the upper pool is adjacent to a much larger pool that is approximately 5 ft below the upper pool (Photo 2). The walls of each pool area and the spires are clad with granite veneer; the bottom of each pool has paving stones set in mortar.

The upper and lower pools have been drained and are not in operation. At the lower pool, water seeps out of the stairs at the pool perimeter, and the granite veneer of the stairs is stained with efflorescence (Photo 3). During one visit, water was flowing out of the special events box at the base of the wall that separates the upper and lower pools (Photo 4). The platform stair at the north side of the upper pool has heavy efflorescence that extends onto the sidewalk pavement at Boylston Street (Photo 1).

## 3.2 Interior Observations of Leakage

During our field visits, we gained access to the interior of the pipe tunnel, pump room and utility vault. These three areas are located below grade and are interconnected by openings within common walls. The pipe tunnel and utility vault are new construction and are separated by the pump room, which is a significantly older construction. During our visit of 28 November 1989, which occurred soon after a period of rain, we documented the location of active leaks and areas with leakage stains. Figure 1 of this report shows leak locations at the roof and walls of the underground vaults. We saw the following active leaks and leakage stains:

### Pipe Tunnel

- Water streams down the face of the concrete walls around the access hatch.
- Water stains and efflorescence at various cracks in the underside of the roof slab.

- Water stains near the areaway vents at each end of the vault.

- Water and efflorescence stains at the ceiling level along the entire length of the south wall (Photo 5).

- Water and efflorescence stains below skimmer boxes in the south wall.

- A large active leak on the face of the south wall, with water flowing from a cold joint in the concrete wall below the skimmer box just west of the west spire (Photo 6).

- Water seeping through penetrations in the south wall for the pipes that service the lower pool (Photo 7).

- Water pooling on the floor that appears to emanate from the joint between the south wall and base slab.

Pump Room

- Active leaks and efflorescence at the underside of the roof slab, particularly along the south wall (Photo 8).

- Leakage at the vertical cold joint between the pre-existing west wall of the pump room and the new west wall of the utility vault.

- Leakage is reported by Mr. Sudholz to occur into electrical panel box P4, from conduits that service the park landscaping.

Utility Vault

- Severe leakage with water streaming down the face of the concrete walls around both access hatches (Photo 9).

- Water stains and efflorescence at cracks in the underside of the roof slab (Photo 10).

- Leakage is reported by Mr. Sudholz to occur into an electrical panel box from conduits that service the landscaping.

## 3.3 Upper Pool Waterproofing

The upper pool forms the roof of the pipe vault. Each of its three sections has a number of penetrations through the floor to accommodate drains, light fixtures, nozzles and other equipment (Photo 11). Before the time of our field investigation, nearly all of the perimeter coping stones and most of the paving stones at the south side of the pool had been removed by others. These removals exposed the perimeter copper flashing and waterproofing membrane to view. In many instances, the waterproofing membrane was damaged or missing from the concrete sub-structure (Photo 11).

- The concrete structure is covered by a black elastomeric membrane with a glass fiber reinforcing mesh. At areas exposed to view on the pool floor, most of the membrane has been removed with only remnants of the original installation left in place.

- At the pool perimeters, a vertical copper flashing flange extends approximately 4 in. above the top of the concrete walls. The waterproofing membrane covers the interior face of the concrete walls, continues onto the copper flange, turns down the exterior face of the flange, and terminates on top of the wall near the base of the flange (Photo 12). Generally, the cavity space between the perimeter concrete walls and the exterior and interior granite veneers is not filled with mortar. Much of the cavity is clear; at some locations there is mortar bedding or mortar debris (Photo 12).

- Stainless steel anchor straps, which secure the top of the granite veneer that lines the interior of the pool, are bolted to the top of the concrete walls. The bolts penetrate the waterproofing membrane; in many instances, the straps are leveled with plastic shims that elevate the bolt heads above the membrane (Photo 13).

- At the south side of the pool, granite overflow channels cantilever over the edge of the upper pool. The copper flashing and membrane are interrupted by the channels; the flashing and membrane stop short of the channels by a variable amount. Photo 14 shows a large gap between the flashing and channel, Photo 15 shows the flashing bent against the face of the channel. Both photos also show that the straps, which secure the overflow channels to the concrete structure, are bolted through the waterproofing membrane.

- Each overflow channel has an anchor block below it that is set into a trough formed within the concrete sub-structure (Photo 14). The waterproofing membrane extends down into the trough and below the anchor block (Photo 16).

- There are three water level sensor probes cast into the top of the concrete walls along the north edge of the pool, one probe for each pool section. The probes have a cylindrical bronze fixture centered on the line of the copper flashing flange (Photo 17). The flashing and membrane have been cut to accommodate the fixture; the flashing has an irregular height of approximately 1 to 2 in. at these locations (Photo 18).

- The overflow outlet fittings located at the east and west ends of the pool are not set flush with the granite veneer (Photo 19). In each case, the metal fitting projects approximately one inch beyond the face of the veneer; the exposed metal has rusted (Photo 19).

- The concrete slabs below the areaway grates at the east and west ends of the pipe tunnel are not covered with a waterproofing membrane.

The granite veneer at the base of each spire's north face and at the top of the platform stairs had been removed by others, exposing the membrane and flashing flange to view (Photo 20).

- The perimeter flashing flange runs continuously from one pool segments, past the face of the spire and along the adjacent pool segment. At the west spire, the perimeter flashing flange appears to have been bent to lay flat on its side (Photo 20). The area where the flashing flange is laid flat on its side is near an area of heavy efflorescence on the platform stairs (Photo 1).

- The membrane waterproofing returns up the face of the spires concrete sub-structure (Photo 21). The membrane terminates above the level of the pool waterproofing; it does not cover the spires concrete sub-structure above the level of the pool.

We also opened the special events box that is located at the base of the wall that separates the upper and lower pools. The box is a formed space within the concrete wall and has a metal frame mounted onto the perimeter of the opening (Photo 22). A bronze face plate with

hinges opens to provide access to the box. The face plate is meant to lock into place against a rubber gasket situated between the face plate and frame. However, the plate rests loosely against the gasket, and there are gaps that can allow water to penetrate into the box.

## 4.0 PRELIMINARY FINDINGS

Based upon our limited review of design documents and our initial field investigation, we have made a preliminary evaluation of the waterproofing for the Fountain and underground vaults. Some issues relating to design, workmanship and systems/materials are subject to change upon greater review of design and construction documents and the results of future exploratory probes to uncover hidden conditions in the field.

### 4.1 Water Leakage

During initial operation of the upper pool the Owner noticed water seeping out of the granite veneer on the south wall of the upper pool and the granite veneer that covers the platform stair at the north side of the upper pool (Boylston Street side). Water also leaked into the underground vaults located below the upper pool and the Boylston Street sidewalk. Because of these leaks, the Owner has terminated use of the Fountain.

At the time of our investigation, the perimeter coping stones of the upper pool and some of the paving stones on its bed had been removed by others. The removal procedures damaged and, in some areas, completely removed the waterproofing membrane from the pool. As a result, we could not conduct watertests that would meaningfully reproduce the leakage patterns that occurred during initial operation. However, our observations of leakage in the vaults after a period of rain provide a basis for assessing the integrity of the waterproofing for the pump room and utility vault, and assessing leakage that occurs when water enters the cavity space between the granite veneer and concrete walls of the upper pool.

#### Upper Pool

Leakage into the pipe tunnel occurs primarily along the south wall that faces the lower pool. Water stains and efflorescence occur throughout the wall, particularly at the intersection with the roof slab (Photo 5) and at horizontal cold joints in the wall (Photo 6). Water seeps through

penetrations in the wall at skimmer boxes and pipes that service the lower pool (Photo 7), and in one location, water seeps through the joint between the base of the wall and floor slab.

Water that enters the cavity space between the concrete wall and the exterior granite veneer eventually penetrates the wall as the water flows downward to the lower pool level. The upper pool waterproofing membrane is shown to terminate at the top of the south wall; the waterproofing membrane of the lower pool is shown to continue up the base of the south wall approximately 2-1/2 ft. The lower pool membrane terminates above the skimmer boxes and other penetrations located near the base of the wall, but approximately 3 ft of the top portion of the wall is without a membrane. Some of the leakage along the south wall is likely due to water penetration through the unprotected concrete wall. Leakage at the skimmer boxes may be due, in part, to water bypassing the top edge of the lower pool waterproofing membrane. Leakage at pipe penetrations and the joint between the wall and floor slab may be the result of water flowing down the wall and bypassing the waterproofing, or may be due to infiltration of ground water below the lower pool. To determine the exact paths of water penetration through the south wall, will require removal of the granite veneer from the walls and portions of the lower pool that abut the wall. Issues relating to design and workmanship can only be evaluated by uncovering the hidden waterproofing and flashings.

During operation of the upper pool, water can flow into the cavity space between the pool's perimeter walls and the exterior granite veneer because the perimeter flashing flange is too low, has gaps or discontinuities at various penetrations, and may have been bent over to lay flat in one location.

- By design, the top of the perimeter flashing flange is approximately 1/2 in. lower than the high water operating level, which can result in overtopping of the flange.

- The waterproofing membrane for the upper pool terminates at the edge of the pool below each of the overflow channels; as a result, water can flow under the channels and into the cavity space of the south wall.

- Gaps between the perimeter flashing flange and the sides of the overflow channels (Photo 19) can also provide a path for water to flow from the pool and into the cavity space of the south wall.

- The large gaps in the perimeter flashing flange at sensor probes (Photo 18) provide a path for water to flow from the pool into the cavity space at the north wall, or onto the concrete sub-structure of the platform stairs that front Boylston Street.

- Because we were not present when the granite coping stones were removed, we are not certain that the flashing flange was installed flat (on its side) at the north face of the west spire (Photo 20). We were told by Mr. Sudholz that the flashing was installed flat and that the coping stone that covered this length of flashing did not have a slot in its bottom face. The breach in the perimeter flashing caused by such an installation problem would account for the heavy efflorescence from water leakage that occurs at the platform stairs near the west spire (Photo 1).

- Also, fasteners that secure the granite veneer to the pools' concrete sub-structure penetrate the waterproofing membrane (Photo 13) and may provide a path for water to flow through the waterproofing membrane, particularly when subjected to a head of water.

The perimeter frame of the hatch door that provides access into the pipe tunnel is not watertight. Gaps in the steel angle frame allow surface water to flow into the tunnel.

The special events box located at the base of the wall that separates the upper and lower pools is not weatherproof. The face plate does not seal tightly against the frame and rubber gasket (Photo 22) when closed in a locked position. Water is reported to leak from conduits that service the special events box. Water that flows downward within the cavity between the granite veneer and concrete wall may leak into the special events box, as well.

Some of the water stains that we saw at the east and west ends of the pipe tunnel ceiling may be due to leakage through the unprotected concrete slabs and walls of the areaways.

### Lower Pool

During the course of our field work, we saw water seeping into the lower pool. The water apparently flows from the adjacent landscaping through the mortar joints between the granite

stair treads (Photo 3). As a result of this water infiltration of the stairs, efflorescence is accumulating on the granite, and the mortar setting bed may deteriorate prematurely.

To determine the source and path of this water infiltration will require the removal of a complete set of treads to expose the underlying waterproofing membrane and connection dowels that secure the granite stair treads to the concrete sub-structure.

### Pump Room and Utility Vault

Water leaks through the roofs at cracks and edges, and water leaks at some wall areas of the pump room and utility vault. The roofs are covered with landscaping and paving materials, and therefore, are not accessible to view. Roof leakage indicates that the new roof membrane of the utility vault has failed its intended purpose, and there is some question, when reading the design drawings, as to whether or not a roof membrane was required for the pre-existing pump room.

Some leakage occurs at vertical and horizontal cold joints in the pump room and vault walls. These walls are located below grade and therefore, their waterproofing elements are not accessible to view at this time.

Water is reported to leak into electrical panel boxes in the pump room and utility vault. The water enters the panel box from conduits that service utilities located throughout the park. To locate the source of water penetration into the conduits will require systematic excavation of successive electrical pull-boxes to establish the extent of conduits that contain water. The affected conduits can then be uncovered and examined to determine the sources of water penetration.

## 4.2 Design Issues Related to Leakage

### Upper Pool

A primary design problem is that the high water operating level for the upper pool is higher than the top of the perimeter flashing system. The design drawings establish the high water elevation at 20.71 ft, and they illustrate in details that the water is above the perimeter flashing;

however, the actual height of the flashing is not shown. The shop drawings for the granite veneer indicate that the top of the flashing is elevation 20.67 ft, and our field measurements confirm that the top of the flashing is approximately at this elevation. As a result the perimeter flashing can be overtopped during operation of the Fountain.

Other design issues related to leakage are as follows:

- Inadequate flashing details for providing a watertight transition between the copper flashing flange and the sides of the overflow channels.
- Use of fasteners for securing granite veneer straps that penetrate the waterproofing membrane below the water line.
- Inadequate detailing for installation of the membrane under the overflow channel; the membrane is shown to terminate below the water line with a free that allows water to flow into the cavity space of the pipe tunnel's south wall.
- Lack of a continuous waterproofing membrane over the entire height of the wall between the upper and lower pools. Water that bypasses the flashing and membrane along the south edge of the pool will flow over the unprotected concrete wall surface.
- Lack of flashing details for the special events box located in the south wall of the pipe tunnel.
- Lack of a waterproofing membrane for the concrete sub-structure at the areaways and planters, which are above the pipe vault space.

Because of the damage that occurred to the waterproofing membrane during removal of the granite and paving, we have not been able to evaluate the membranes performance. Our experience with liquid-applied membranes similar to the specified Laticrete system is that they have performance problems associated with reflective cracking and lack of accessories to fabricate integral, watertight flashings. The reinforcing fabric used in the Laticrete system helps to limit crack formation; we remain concerned for the longevity of flashings that are adhered to penetrations in submersed conditions. The use of a relatively flexible and thin metal as a form

for the perimeter flashing is a poor design choice, particularly when used as a support substrate for a liquid-applied membrane. Also, copper has a high thermal coefficient of expansion; thermal movements at transverse seams in the copper can be transferred to the adhered waterproofing membrane causing fatigue cracks, in time.

### Lower Pool

Water seeps into the lower pool from the adjacent landscape areas and has resulted in accumulation of efflorescence at the granite stairs. Further field work is required to document the source of the water; however, the design drawings and shop drawings show dowels and anchor straps that penetrate through the waterproofing membrane with no cap flashing to preserve the integrity of the waterproofing system.

### Underground Vaults

Design issues that may relate to leakage problems in the various underground vaults are as follows:

- Lack of a footing drain at the base of the pipe tunnels south wall (i.e. the wall between the upper and lower pool). Placement of footing drains at other vault walls above the level of the wall to floor slab cold joint.
- Unclear requirements for installation of water stops at wall-to-floor joints.
- Generalized, vague waterproofing requirements for the roof of the utility vault, with inadequate requirements for membrane protection.
- Lack of a waterproofing membrane over parts of the pump room roof.
- Lack of flashing details for sealing the perimeters of all access hatches (trap doors).

## 4.3 Workmanship Issues Related to Leakage

To properly evaluate the quality of the installed work and compliance with the plans and specifications by the contractor, will require uncovering various sections of the Fountain and

vaults. These areas are currently covered by landscaping, paving and granite veneers; removal of these elements to expose the underlying construction will require a significant field effort. Workmanship problems that we have seen to date are as follows:

**Upper Pool**

- The perimeter copper flashing is cut irregularly to fit by the sensor probes; the height of the flashing is 2 to 3 inches lower than adjacent flashing and provides large breaches in the pool waterproofing barrier. There are three of these flashing conditions on the north side of the pool.

- The perimeter copper flashing terminates short of the overflow channels. The gaps between the flashing and channels are variable, as great as 2 inches in some locations. These gaps exacerbate the inherent design problem of an inadequate transition detail between the flashing flange and overflow channels.

- Improper installation of the flashing flange at the north side of the west spire. The flashing is bent flat on its side, providing a breach for water to flow from the pool into the platform stairs.

- Installation of the waterproofing membrane under the anchor blocks of the overflow channels, instead of on top of the anchor blocks, has increased the probability of water leakage at these locations. The membrane extends down into a trough below the anchor blocks and is subject to a larger pressure head that tends to force water to flow from the membrane into the south wall cavity.

The design drawings indicate that all granite veneers are to be set solidly in a mortar bed against the concrete sub-structure walls. Most of the granite veneer was installed with an open or partially blocked cavity space. As a result, water that leaks through the upper pool flashing system flows readily into the cavity spaces and onto unprotected concrete wall surfaces. However, even if the cavity space had been filled with mortar, we would expect water to eventually penetrate through the mortar to the concrete walls. One disadvantage to filling the cavity space with mortar is that efflorescence tends to form on the granite when water flows into the mortar/cavity space, saturates the veneer and mortar, and then dries.

### Lower Pool and Underground Vaults

Because the waterproofing elements for the lower pool and underground vaults are not accessible to view, we cannot comment on their workmanship or as-built condition. A program of selective disassembly to view hidden conditions for these areas is presented later in this report.

## 4.4 Future Investigative Work

This report is preliminary; it is intended to present, in broad form, the various leakage and/or deterioration problems that are evident from our surface observation of the Fountain and the interior of the vaults. We have briefly reviewed the design drawings to establish the basic design for the Fountain waterproofing systems; we have not reviewed all pertinent details of the various systems or related construction correspondence.

To evaluate conclusively the various leakage problems presented in this report, and to assess responsibility among the various parties involved in the design and construction of the Fountain, will require a significant field investigative effort. This is particularly true concerning the waterproofing of the underground vault areas. Because of their buried condition and the granite veneers that clad portions of their roofs and walls, significant construction labor will be incurred to expose the various waterproofing systems.

We suspect that the effort for some of the excavation work may be so great as to warrant simultaneous repair or replacement of the affected waterproofing system. For example, the roof of the new utility vault has failed as evidenced by the roof leaks we saw from the interior. To determine the cause of the roofing failure will virtually require complete excavation of the sidewalk pavement and overburden above the vault. Once the vault is uncovered, it seems appropriate to proceed with repair or replacement, as necessary, of the roof membrane.

For your consideration we have developed the following list of field investigative activities to uncover hidden conditions of the various Fountain components:

## Upper Pool

Conditions at the upper pool are fairly well defined at this time, because of the extensive removal of stone cladding by others. The waterproofing system is unfit for its intended purpose, and because significant portions of the waterproofing are damaged or missing, the entire system should be replaced in accordance with our recommendations at the end of this report.

- The entire granite veneer that covers the south facing wall that separates the upper and lower pools will most likely need to be removed as part of the upper pool repairs. The removal of the veneer will allow installation of a continuous waterproofing membrane over the entire height of the wall, and will allow documentation of existing flashing conditions at the skimmer boxes and special events box. Meanwhile, portions of the veneer should be removed to complete the investigation of the upper pool waterproofing and to prepare a remedial design.

- A portion of the granite and mortar paving that covers the platform stairs, which front Boylston Street, should be removed down to the concrete sub-structure. This area is above the pump room; the existence and/or condition of a waterproofing membrane can be verified.

## Lower Pool

- The granite paving on the lower pool floor at its intersection with the pipe tunnel wall should be removed to allow inspection of the waterproofing and flashing around the pipes that penetrate the pipe tunnel below the level of the lower pool.

- A complete set of granite treads should be removed from a typical perimeter stair, to allow inspection of the waterproofing membrane and dowel penetrations through the membrane.

## Underground Vaults

- The roof of the new utility vault should be completely uncovered to allow inspection of the roof membrane.

- The west wall of the new utility vault and pump room should be completely excavated to allow inspection of the wall drainage composite, footing drains and the vertical cold joint between the new and old construction.

- The access hatches for the new utility vault and the pipe tunnel should be excavated to allow development of waterproofing repairs for their perimeter frames.

## 5.0 RECOMMENDATIONS

### Upper Pool

To remedy the leakage problems and to preclude long term deterioration of the pipe tunnel structure requires complete reconstruction of the upper pool waterproofing system. If the pool is to maintain its current water operating level and the feature of water flowing through the overflow channels into the lower pool, then most of the pool's perimeter walls must be made taller and the waterproofing for the south facing wall between the upper and lower pools must be redesigned to resist and weep water that flows into the cavity space between the concrete wall and its exterior granite veneer. The repair scheme with the greatest probability of success would consist of:

- Removing the paving bed, interior granite veneer (liner), overflow channels, exterior granite veneer on the south facing wall that separates the upper and lower pools, and the existing waterproofing membrane.

- Raise the concrete walls at the north, east, and west sides of the pool to allow the new waterproofing membrane to extend 8 inches, minimum, above the high operating level.

- The new waterproofing membrane should continue across the top of the new walls and turn down the exterior face a minimum of 12 inches. At the south side of the pool, the new waterproofing membrane should continue down the face of the wall and lap over the waterproofing membrane of the lower pool. A flashing should be installed at the base of the south wall to collect water that flows within a clear cavity space and weeps it to the exterior just above the surface of the lower pool.

- The granite veneer that clads the upper pool walls should be made taller; all strap anchors should be located at the top of the wall, well above the water level.

- The new waterproofing membrane should continue into the spires and cover the entire concrete sub-structure of the spires.

- Waterproofing should also be applied to the concrete slabs and walls below the areaway grates.

- All penetrations should be properly flashed into the new system.

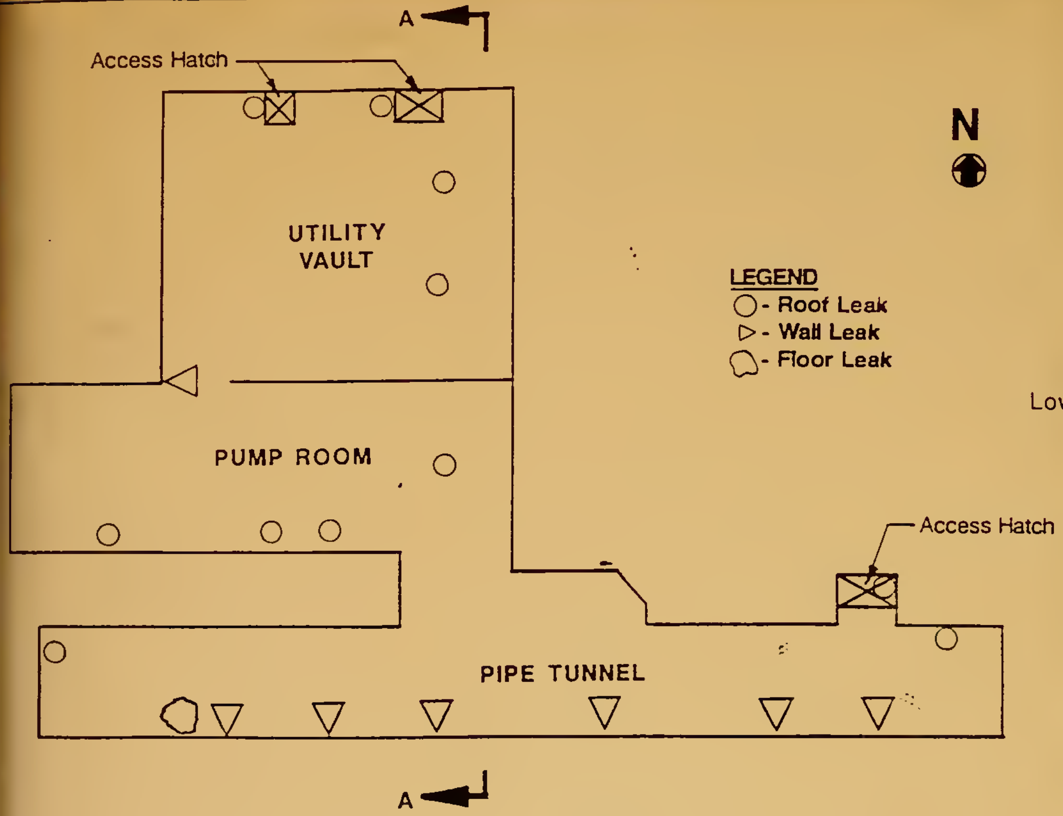
The repair option presented above is conceptual and should only be used for planning purposes. Implementation of remedial work should be accomplished with complete plans and specifications, and should be monitored on a full-time basis by a technician trained in waterproofing applications.

Respectfully submitted,

SIMPSON GUMPERTZ & HEGER INC.

Stephen S. Ruggiero
SSR1-90.ct

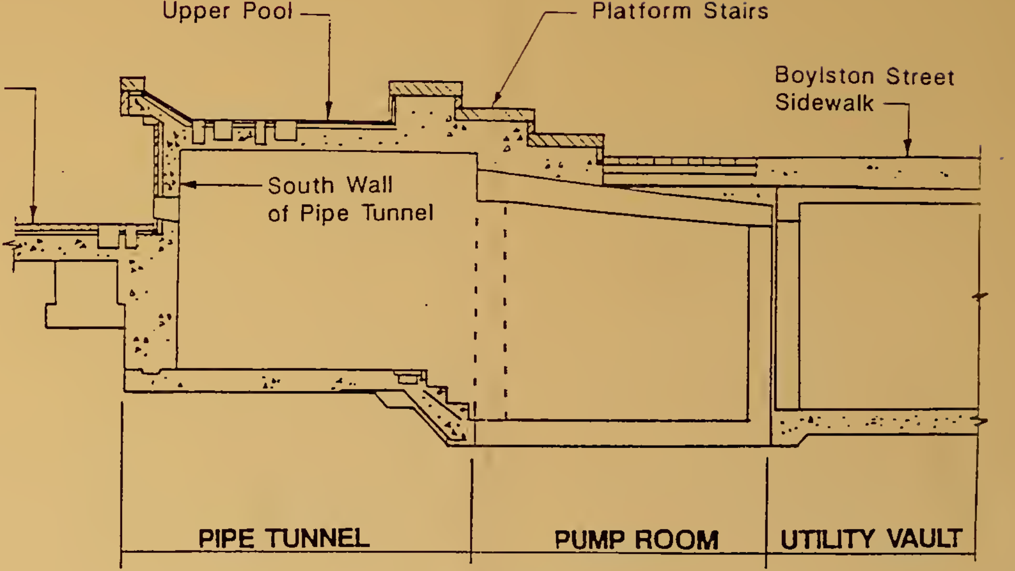
Encls.



PLAN

## LOCATION OF LEAKS - UNDERGROUND VAULTS

Not to Scale



Section A - A

| | | | | | |
|---|---|---|---|---|---|
| Simpson Gumpertz & Heger Inc.<br>consulting engineers<br>297 Broadway, Arlington, MA 02174<br>(617)643-2000 FAX 643-2009 | | | | LEAKAGE INVESTIGATION<br>COPLY SQUARE PARK FOUNTAIN<br>BOSTON, MASS | Figure<br>[illegible] |
| Comm: 89315 | Date: 1/3/90 | Drawn: OLJ | Checked: SSR | | |

Photo 1

Photo 2

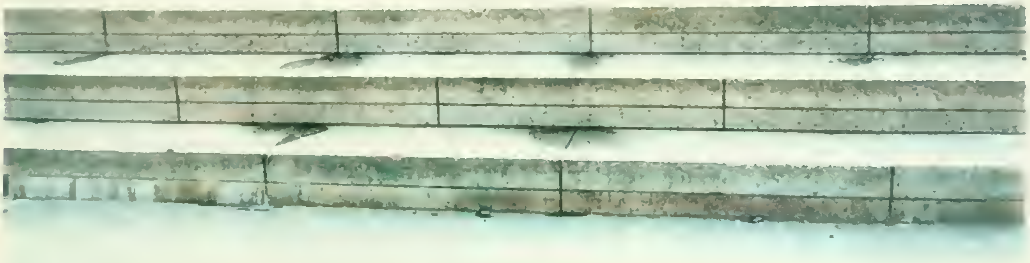


Photo 3

Photo 4

Photo 5

Photo 6

Photo 7

Photo 8

Photo 9

Photo 10

Photo 11

Photo 12

Photo 13

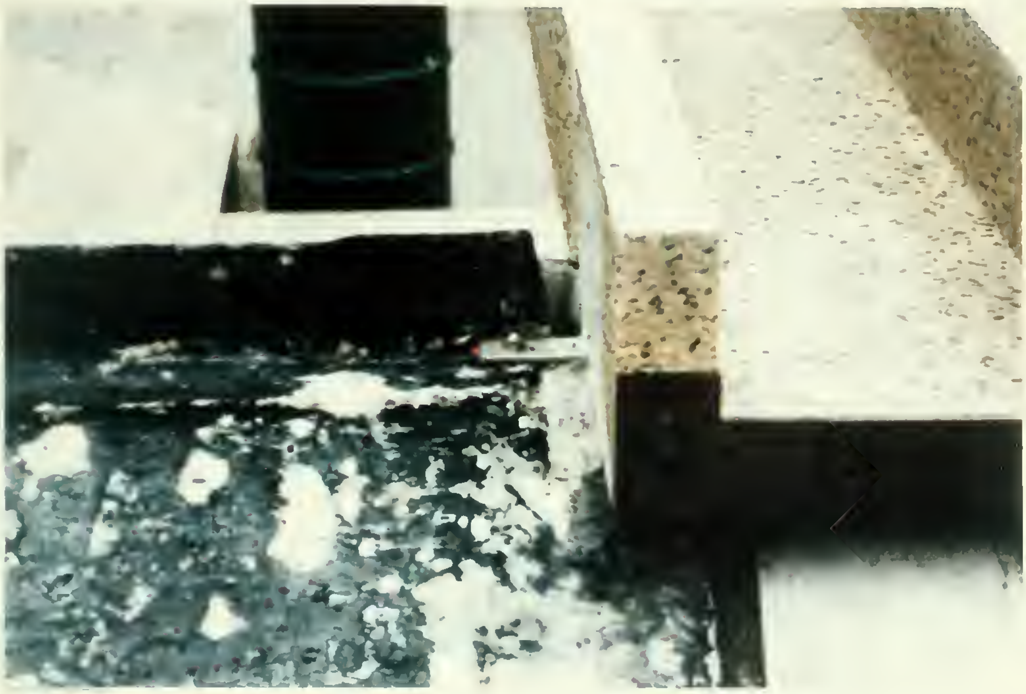


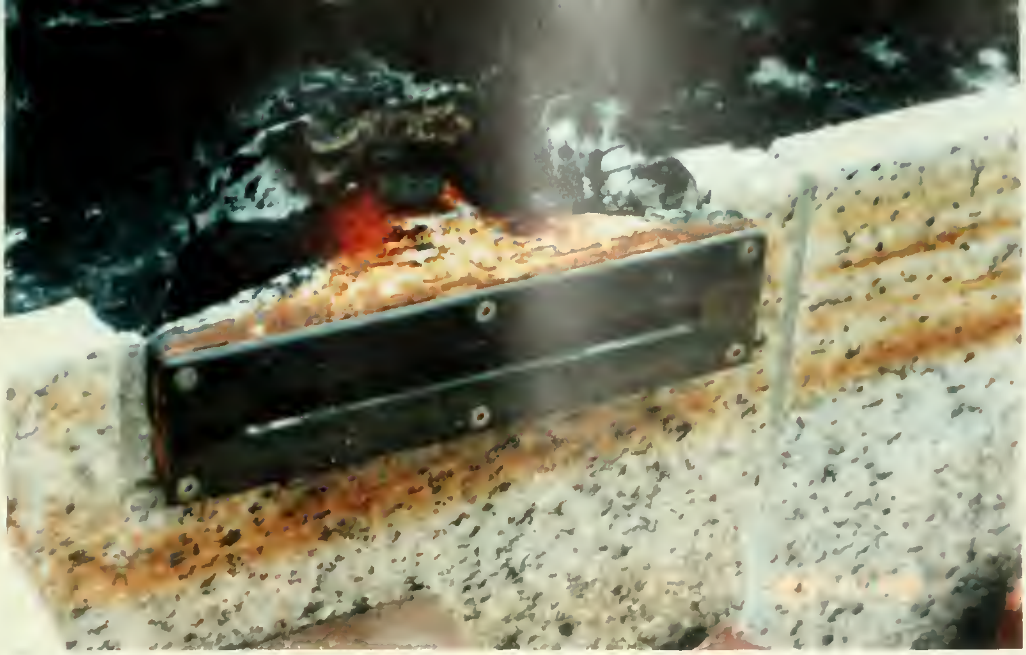
Photo 14

Photo 15

Photo 16

Photo 17

Photo 18



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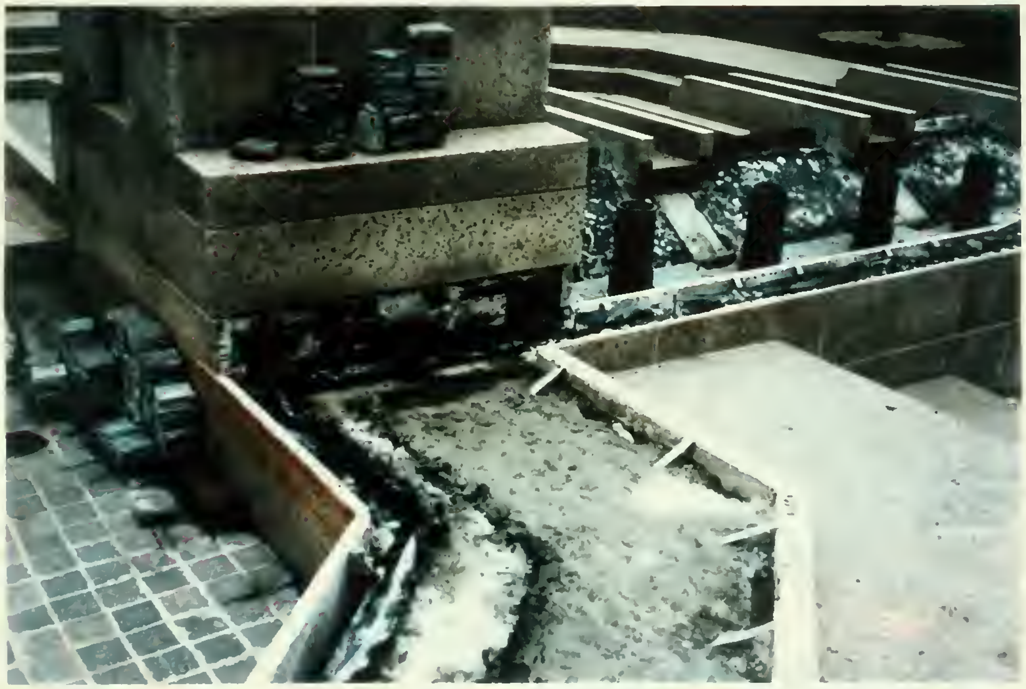

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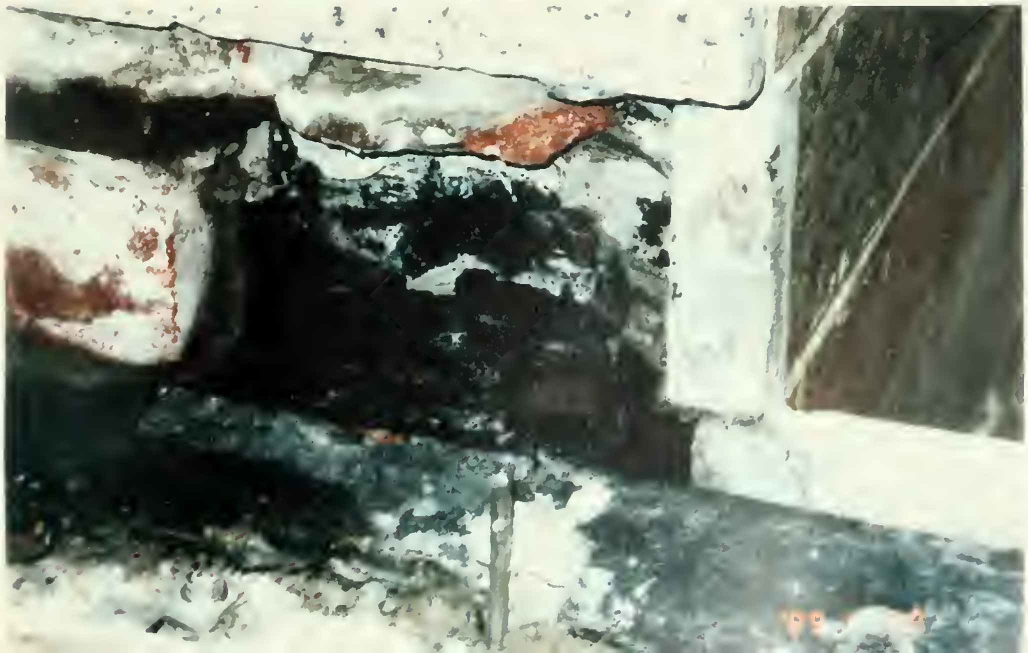

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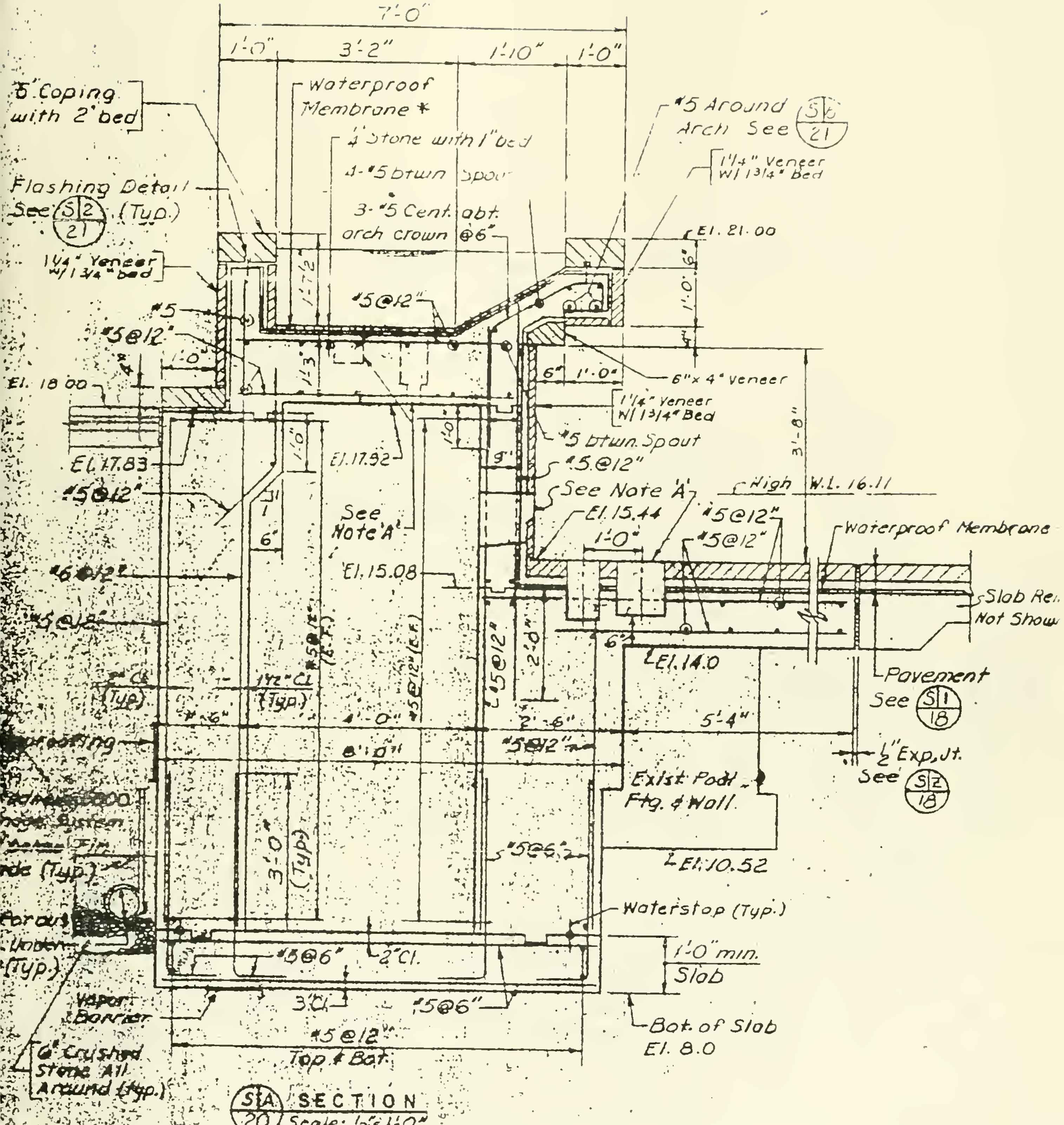
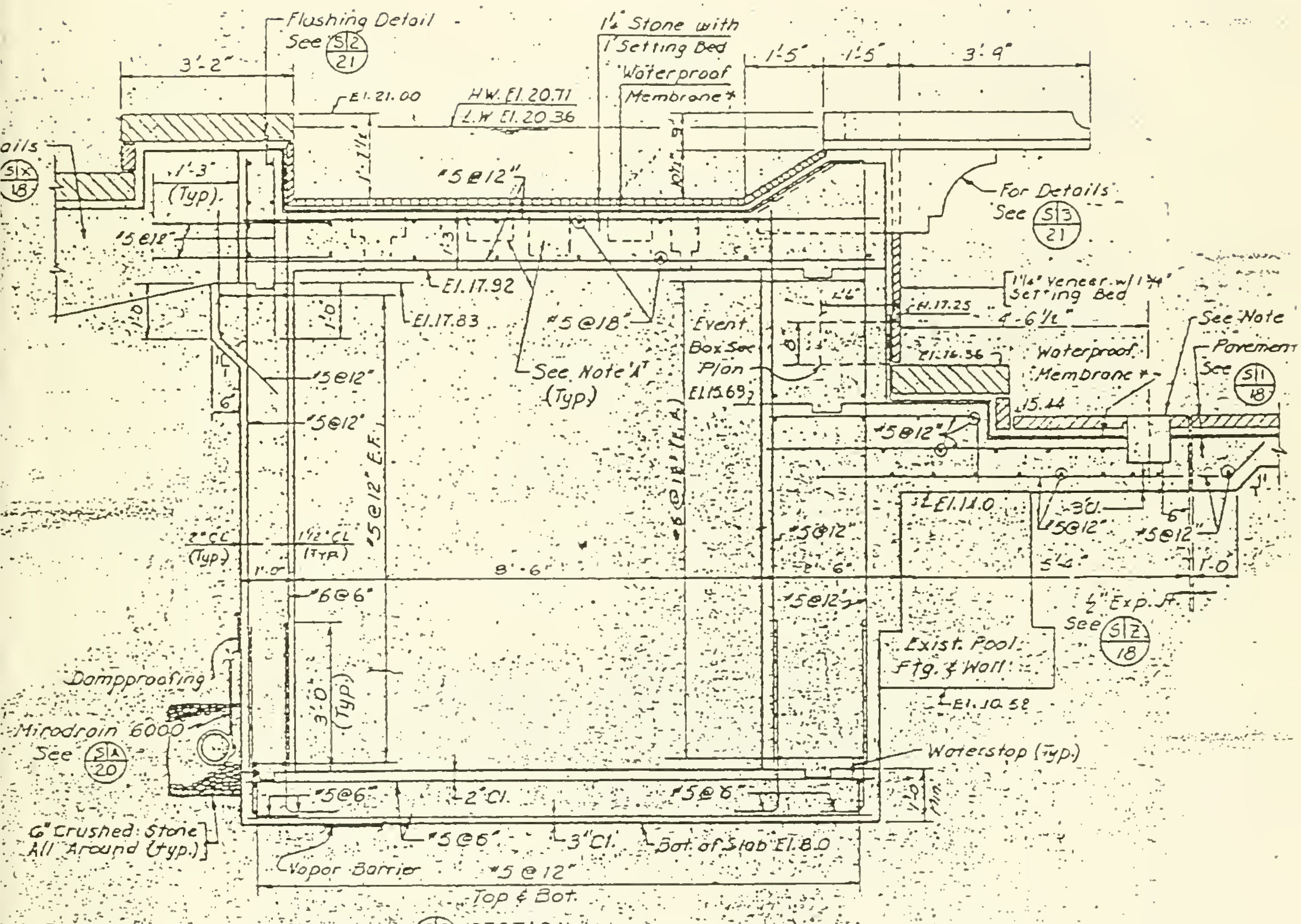
Photo 22

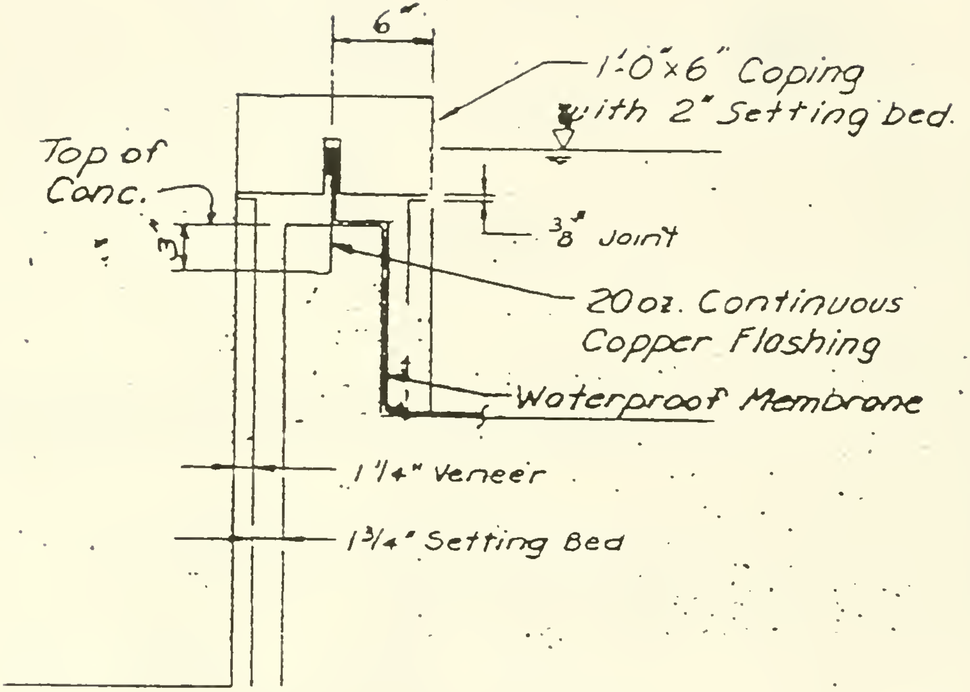


S A / 20 SECTION Scale: 1/2"=1'-0"

* Waterproof Membrane
For lower Pool place on all Vertical Surfaces to El. 17.25
For upper Pool place as shown on drawing.



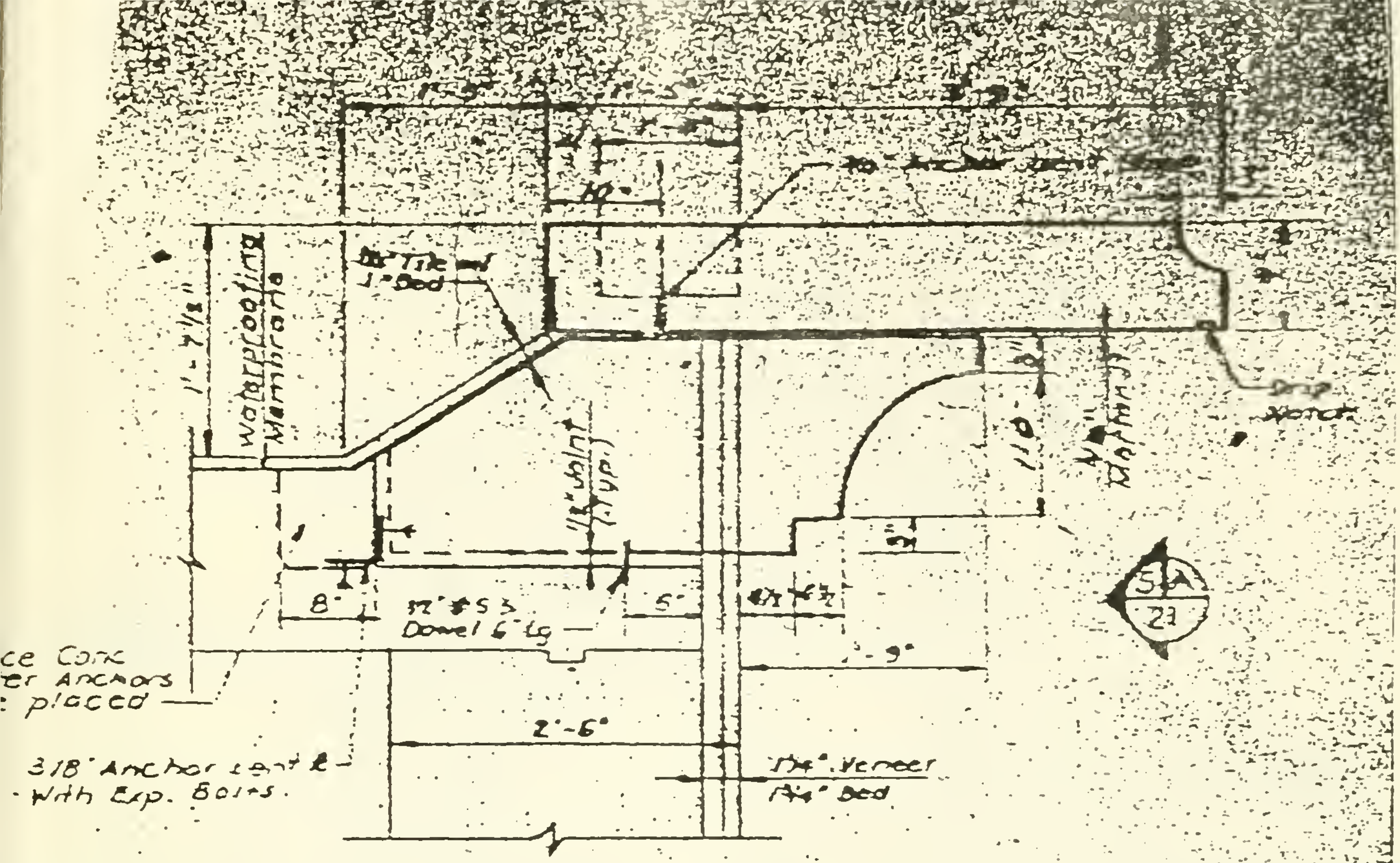
S5B/20 SECTION
Scale: ½"=1'-0"



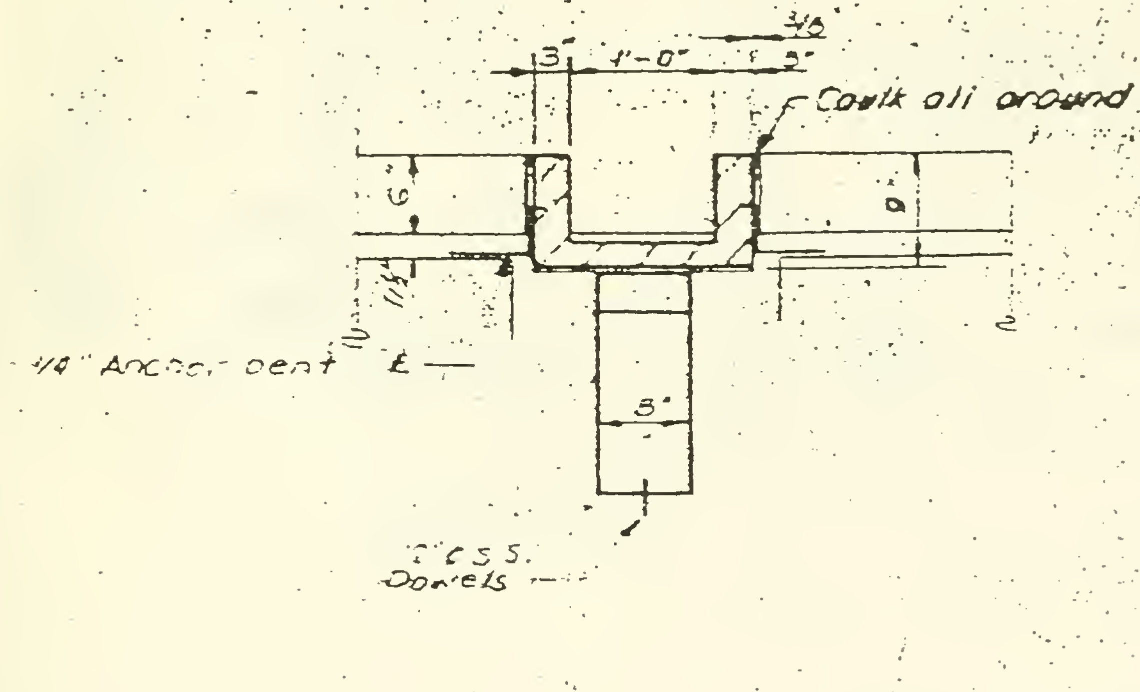
S 2
21

TYPICAL FLASHING AT COPING OF UPPER POOL

Scale . 1"=1'-0"



S 3 / 21 OVERFLOW CHANNEL DETAIL
Scale 3/4" = 1'-0"



S A / 21 SECTION
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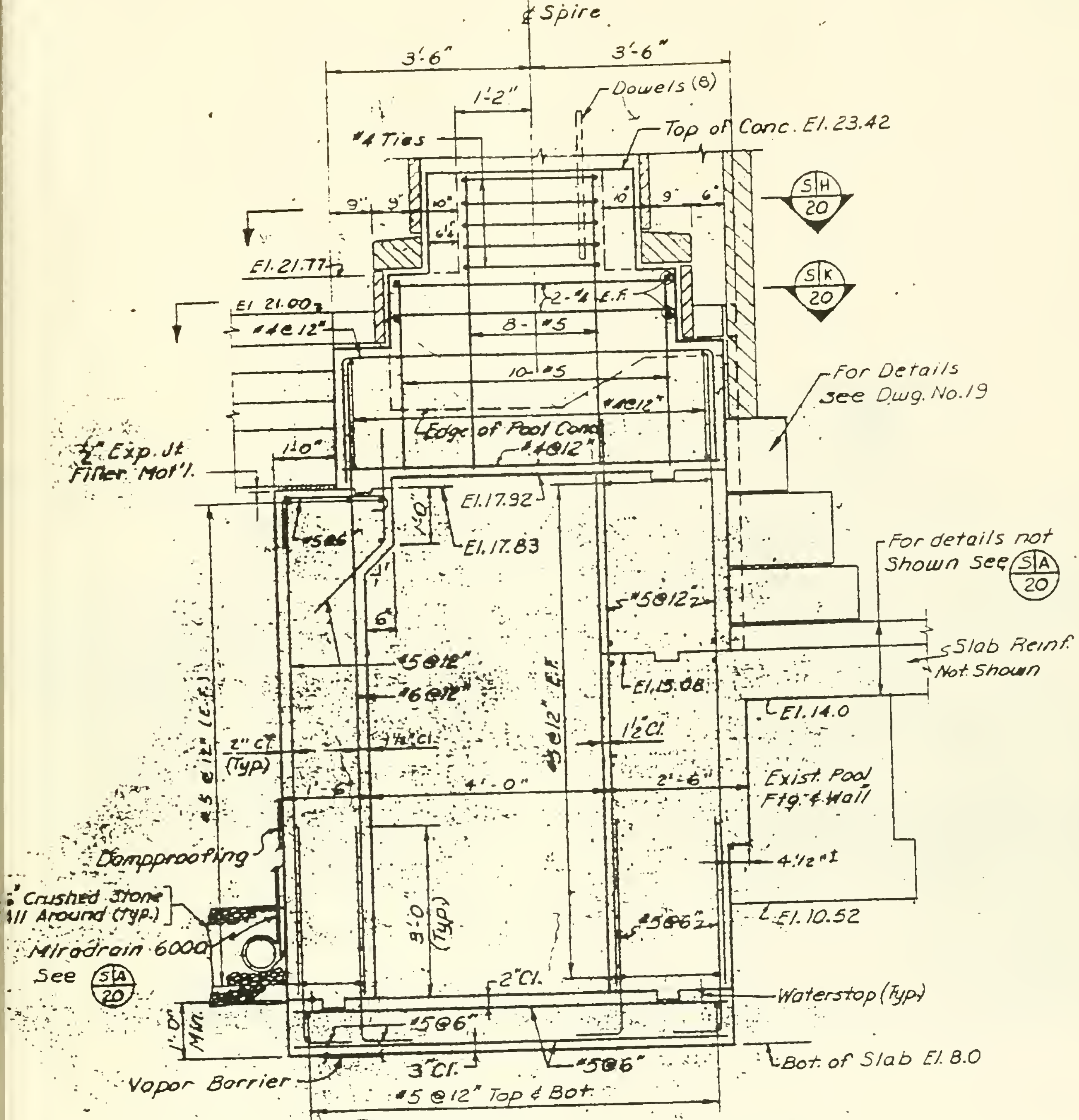
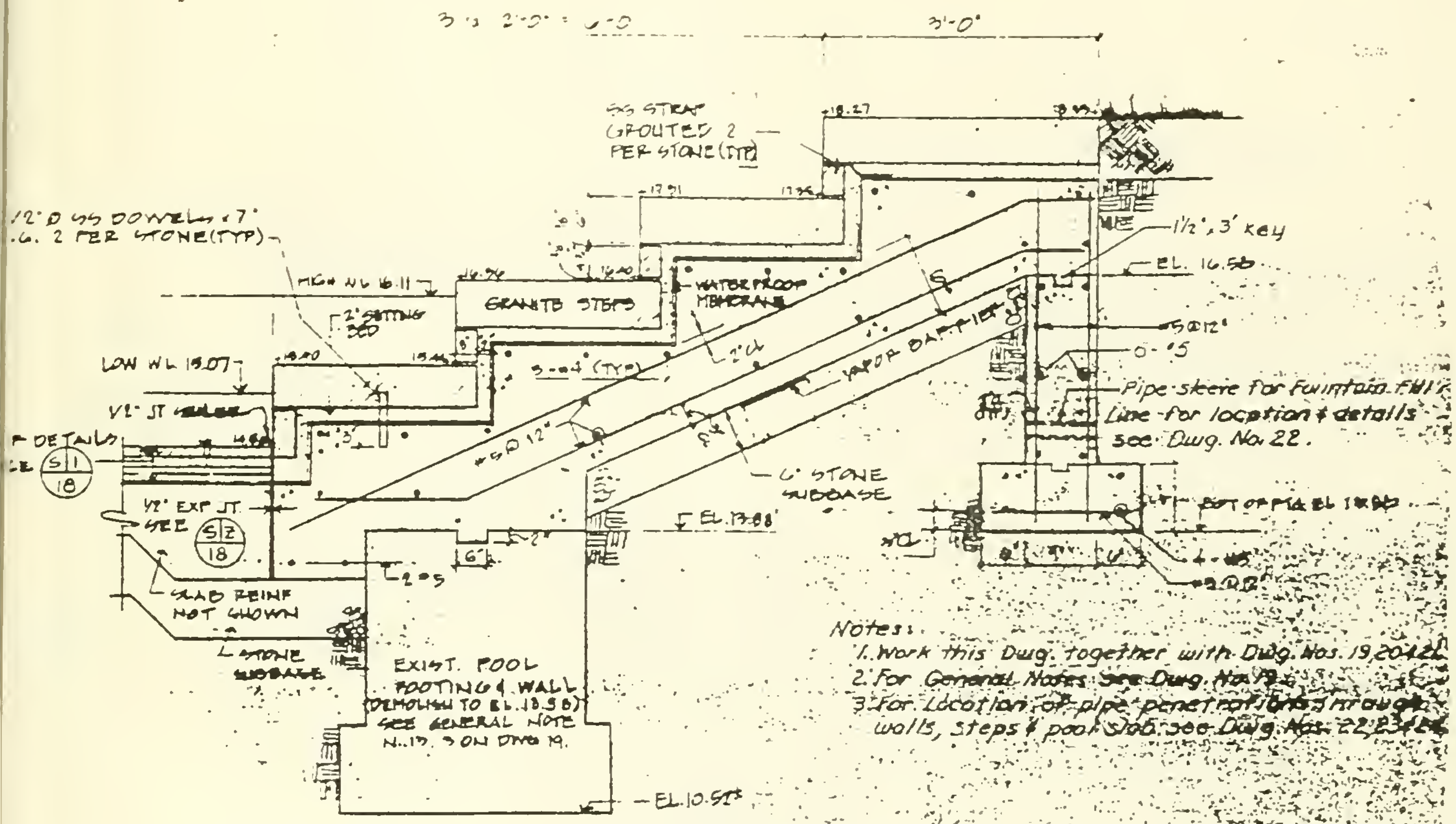


S C / 20 **SECTION**
Scale: ½"=1'-0"

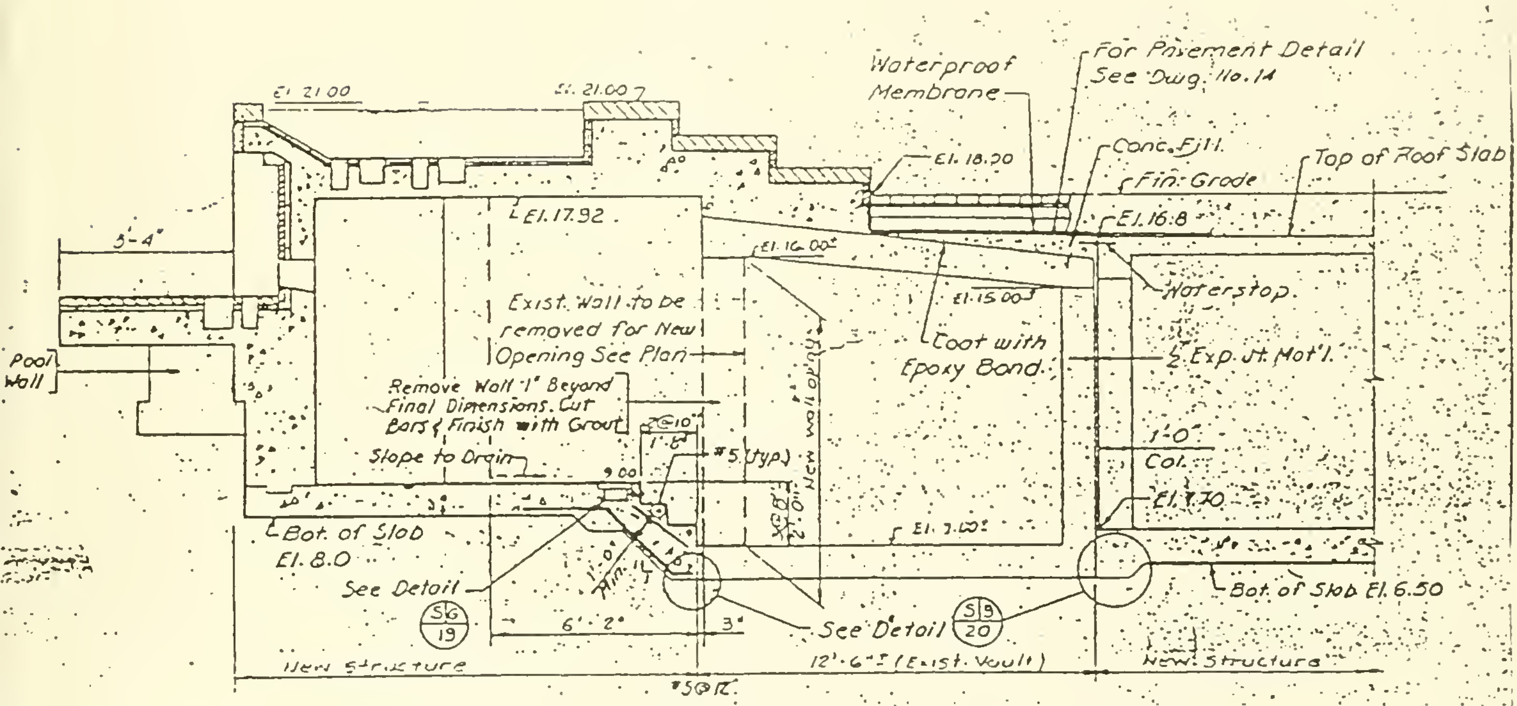


Notes:

1. Work this Dwg. together with Dwg. Nos. 19,20&22
2. For General Notes see Dwg. No. 19.
3. For location of pipe penetrations through walls, steps & pool slab see Dwg. Nos. 22,23&2

S/V 18 LOWER POOL STEP SECTION

SCALE 3/4"=1'-0"



S D
20
SECTION
Scale: 1/4"-1'-0"

264

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